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Hot-Melt Adhesive Component Layers for Smart Cards

The invention relates to a multilayer composite, to a process for producing it, and to the use of thermoplastic hot-melt adhesives for producing said composite.

The present invention is concerned predominantly but not exclusively with the production of what are known as smart cards. By a smart card is meant a generally multilayer article in the form of a plastic card, which is commonly provided with information and/or advertising imprints and/or with security features, such as a photo of the cardholder, a magnetic strip, an identification symbol in the form of a hologram or the like. This smart card commonly consists of a plastic card laminated on one or both sides. Embedded in the body of the smart card is what is known as a module, whose key constituent is an electronic circuit (chip). This chip may be seated on a support plate which in one particular embodiment is provided with a plurality of electrically conductive surface segments. This segmented electrical contact area is accessible from the outside so that information, e.g. data and identification features, may be exchanged by way of these contacts with external computers and/or control equipment.

Newer types of card include an antenna connected electrically to the chip within the card body, so that by way of this antenna there is the facility both for contactless electronic exchange of information and for contactless supply of energy to the chip in the card body. Smart cards of this kind are used or envisaged as telephone cards, authorization cards for mobile communication devices, check cards in monetary

transactions, proofs of authorization for health insurance organizations, driver's licenses, train tickets, and bus tickets. The user inserts the contactless smart card into a card reader or moves it at a distance past the reader, which communicates with the electronic circuit in the smart card by way of a corresponding antenna facility. In this way it is possible, for example, in the case of a telephone card or a check card or a rail ticket, to check the presence of funds, to ascertain an identity, or to perform some other data exchange.

Production processes for the contactless smart cards are known in principle. For instance, WO-A-98/09252 describes a multistage production process. In that process, the so-called component layer or card body is provided with openings, depressions or similar cavities, after which the electronic components to be disposed in the card body are inserted into these cavities, then the card body is coated with an adhesive in such a way that the cavities are filled and the adhesive forms a substantially planar surface. Subsequently, a cover film is applied to the surface of the adhesive, which has not yet set or fully cured and which is therefore still plastically deformable. The face of the cover film remote from the card body is then held fixed on a shaping surface in such a way and for sufficient time, during the curing of the adhesive, that the external contour of the cover film and thus the external contour of the finished smart card corresponds to the contour of the shaping surface. The adhesive proposed is a cold-curable adhesive, in particular an epoxy adhesive. In order to prevent shrinkage of this adhesive, it must be filled with a filling material such as glass, quartz or the like.

This production process comprises many worksteps and is time-consuming and therefore very costly.

EP-A-0 692 770 describes a process in which the chip and the antenna are introduced into the cavity of an injection mold, after which a thermoplastic material is injected into this mold, where appropriate in a plurality of worksteps. The thermoplastic material proposed comprises typical injection molding materials such as PVC, ABS (acrylonitrile-butadiene-styrene terpolymer), polyethylene terephthalate (PET), polycarbonate (PC) or polyamide (PA). Such injection molding materials require very high temperatures during processing, and high pressures of, for example, 700 kg/cm^2. Such high pressures and temperatures are, however, very poorly suited to the sensitive electronic circuits to be embedded, with the consequence that these circuits often suffer damage.

EP-A-0 709 804 proposes, in a multistage injection molding process, first inserting a plastic disk into the injection mold, the antenna being placed on said disk. Subsequently, a liquid polymer material (mention is made specifically of ABS, PC, PET, polyamide or reactive resins curable at higher temperatures such as polyurethane, epoxy-phenolic resins) is spread over the surface of the antenna, with the antenna connections being left exposed. Subsequently, a plastic film which closes the hole in the card is placed over the antenna. This plastic film has an indentation into which the electronic chip is accommodated in such a way that it is in electrical contact with the antenna contacts. This procedure also necessitates high temperatures and high pressures for the injection molding steps; furthermore, additional worksteps are necessary in order to insert the electric circuit into the card

body, to fix it and to connect it electrically to the antenna.

JP-A-08 276 459 describes a production process for contactless smart cards in which the component support comprises a glass fiber reinforced epoxy resin which has an indentation and, where appropriate, comprises conductor tracks, including that for forming the antenna. The electronic chip is introduced into the indentation of the component layer. Subsequently, this entire component is inserted into an injection mold and, after the mold has been closed, a liquid, thermosetting polymer material is injected into it at low pressure and is cured therein. Specifically, a thermosetting epoxy resin is proposed for this purpose. The curing of the epoxy resin takes 4 to 5 minutes; after the molding has been removed from the mold, after-curing by heating at a certain temperature for a certain time is necessary - specific details of this aftercure are lacking.

EP-A-0 350 179 describes a production process for smart cards and similar electronic tokens with the aid of a reaction injection molding process. The electronic circuit is encapsulated by a layer formed by the reaction injection molding material. The cover films of the two flat sides of the card are supplied to the mold in the course of injection molding in such a way that they serve simultaneously as mold release agents for facilitating the removal of the cured card body from the injection mold. Specific details regarding the composition of the polymer for the reaction injection molding process are not given; all that is said is that it is possible to take any polymer material or any polymer blend that cures under reaction injection molding conditions. Owing to the precision metering

equipment they entail, reaction injection molding machines are known to be expensive and complicated.

EP-A-0 846 743 describes a thermoplastic, heat-curable, self-adhesive sheet for implanting electric modules into a card body which is provided with a cutout into which it is intended an electronic module should be arranged, said module having on the first side a plurality of contact areas and on the opposite side an IC chip whose contacts are connected by electrical leads to the contact areas. The adhesive sheet is to be composed of a thermoplastic polymer, one or more tackifying resins and/or epoxy resins with hardeners, and also accelerators, where appropriate. These adhesive sheets have to be heat-cured at approximately 150°C for 30 minutes.

JP-A-05 270 173 describes a process for producing laminated sheetlike polymer structures for blank card bodies. For this purpose, two rigid PVC sheets are coated with a film of a moisture-curing polyurethane hot-melt adhesive from 5 to 50 µm thick at from 100 to 120°C and are compressed for 10 seconds under a pressure of 5 kg/cm^2. One of these sheets has a cutout, or a cavity produced by thermoforming, intended to accommodate the microprocessor that is to be inserted subsequently. Thereafter, these sheetlike structures are left at room temperature for several hours without pressing, so that the adhesive cures to give a card base material which can be processed to the finished smart card in further processing steps.

An object of the invention was therefore to develop a gentle, quick and easy process for producing smart cards, permitting cost-effective large-scale manufacture of such smart cards.

The inventive achievement of the object is set out in the claims. It essentially comprises the use of thermoplastic hot-melt adhesives for producing the component layers of smart cards, and a process for producing said smart cards wherein the thermoplastic hot-melt adhesives can be used at low temperatures and low pressures in the low-pressure injection molding process.

As thermoplastic hot-melt adhesives it is preferred to use the low-melting polyamides based on polyaminoamides, thermoplastic polyurethanes or atactic polypropylene, or a blend thereof, to produce the component layer. These thermoplastic hot-melt adhesives feature a low viscosity of from about 100 to 100 000 mPa.s at the processing temperature. As a result, they can be used in the low-pressure injection molding process at pressures of between 1 and 50 bar, preferably at injection pressures of between 10 and 30 bar. The processing temperatures are guided by the composition of the hot-melt adhesive material; they are situated at between 80°C and 250°C, preferably between 100°C and 230°C. The polyamides to be used with preference generally have a viscosity of less than 10,000 mPa.s at 210°C. Particularly preferred ranges of the processing viscosities at 210°C are situated at between 1,500 and 4,000 mPa.s, this viscosity usually being measured using a Brookfield viscometer of the RVDV II type with Thermose facility.

In particular cases, reactive, moisture-postcrosslinking polyurethane hot-melt adhesives may be used instead of the aforementioned thermoplastic hot-melt adhesives. The moisture-reactive polyurethane hot-melt adhesives, although involving increased effort during application owing to their moisture sensitivity,

have an advantage which lies in the markedly lower viscosity at processing temperatures: reactive polyurethane hot-melt adhesives generally have viscosities at 130°C of < 25 000 mPa.s, preferably indeed below 15 000 mPa.s, and with very particular preference below 10 000 mPa.s at 130°C, the viscosity customarily being measuring using a Brookfield viscometer of the RVDV II type with Thermosel facility. An advantage of the use of moisture-curing polyurethane hot-melt adhesives is their low melting point, which is generally below 100°C, preferably below from 70 to 80°C, so that even very temperature-sensitive circuits may be embedded using these hot-melt adhesives and even very temperature-sensitive laminating films may be used. Their postcrosslinking with moisture results in the formation of a particularly resistant and temperature-stable bond between component layer and base film and cover film.

Through the use of the thermoplastic hot-melt adhesive to produce the component layer, the subsequent milling to produce the space require to accommodate the chip, or chip and antenna, becomes unnecessary, since these parts to be encapsulated may be placed in the corresponding encapsulation mold prior to the finishing of the base structure. During the subsequent encapsulation process, chip, or chip and antenna, are surrounded by the base body thus produced (component support) such that there is no longer any subsequent need either for additional fixing or for any cushioning or surround-filling of the electronic components. Moreover, when the printable or printed base film and cover film are applied, it is possible to forego additional application of adhesive to the component support, since the latter is of course itself

manufactured of adhesive and, following appropriate activation by heating if desired, forms a secure bond with the base films and/or cover films.

In accordance with the invention, all thermoplastic, reactive and nonreactive hot-melt adhesives may be used to produce the card base body, provided they can be processed at temperatures between 80°C and 250°C, preferably between 100°C and 230°C, in the low-pressure injection molding process, i.e., their processing viscosity should be situated at between 100 and 100 000 mPa.s. The pressure range for the low-pressure injection molding process is situated in the range from 10 to 30 bar, particular preference being given to a range for injection molding of between 10 and 30 bar. This ensures that the inserted chips or other electronic storage media used can be surrounded gently and not damaged and destroyed as in the regular injection molding process by means of high injection pressures (500 to > 1 000 bar).

Depending on the nature of the base film and cover film used for the finished card, and on the stiffness and elasticity requirements of the card body, and the possible temperature stresses thereon, the hot-melt adhesives may be selected from the conventional groups of polyamide (especially polyamidoamide based on dimerized fatty acids), polyurethane, polyesters, ethylene-vinyl acetate (EVA) copolymer, low molecular mass polyethylene copolymer, atactic polypropylene (APP), or combinations thereof. As already mentioned above, it may be advantageous in particular cases to use reactive hot-melt adhesives based on moisture-postcrosslinking polyurethanes instead of the aforementioned thermoplastic hot-melt adhesives.

As the base film and/or cover film it is possible here to use all films known in principle for this purpose; examples that may be mentioned include films based on polyester, especially polyethylene terephthalate (PET), polyvinyl chloride (PVC), acrylonitrile-butadiene-styrene (ABS), polycarbonate (PC) or polyimide. These films usually have thicknesses of up to 100 μm; preferably, the film thicknesses are situated in the range between 30 and 70 μm.

In the production process of the invention, a variety of procedures can be adopted. Firstly, the chip and the associated antenna, where appropriate, may first be placed in the injection mold of the injection molding unit, it being possible for the chip and antenna to be in preassembled form on a support film, for example. After the mold has been closed, the hot-melt adhesive is then injected. After brief cooling, the mold can be opened and the component layer thus produced removed from the mold. No further application of adhesive is required for the subsequent lamination with a base film and/or cover film, since the matrix of the card body layer acts itself as an adhesive: all that need be done is to compress the films with the component layer, with heating where appropriate.

Alternatively, a thin film of the hot-melt adhesive may be placed in the injection mold, and the electronic component and the antenna placed thereon. Subsequently, the mold is closed and the electronic components are completely encapsulated by the injection of further hot-melt adhesive material. Again, no further application of adhesive is necessary for lamination with the base and/or cover film, since here again, with heating where appropriate, the films can be compressed with the component layer and so are

connected permanently to the layer. The film thickness of the hot-melt adhesive matrix including the encapsulated chip is presently in general between 400 and 600 μm, preferably 500 μm, but may turn out to be thinner or thicker depending on the type of chip.

For the embedding of the electronic component and the antenna into the matrix of the card support layer comprising the hot-melt adhesive, it is possible in one particularly preferred embodiment to use a low-pressure processing system from Optimel Schmelzgußtechnik. The preferred embodiment of the injection mold is depicted in figures 1 to 3. Of these figures,

Fig. 1 shows a plan view of the bottom part of the injection mold,

Fig. 2 shows a side view of the top part of the injection mold,

Fig. 3 shows a detail of the top part.

In accordance with **Fig. 1**, the bottom part 1 of the injection mold possesses a cutout 2 whose length and width correspond to the dimensions of the top part of the injection mold. The bottom part of the injection mold further comprises the runner 3, which is designed so that the hot-melt adhesive is able to fill the entire mold, fully and without bubbles, within very short cycle times. Moreover, the shape of the runner is designed so that the sprue remaining on the card body can be removed easily after the card body has solidified.

Fig. 2 shows a cross-sectional view of the upper part 4 of the injection mold across the line A-B of Fig. 1. In its upper marginal region this top part has a projection 5, so that when the top part engages in the cutout 2 of the bottom part a fully closed chamber is formed in the injection mold. The cutout 6 of the

top part 4 corresponds in its length and width dimensions to the card support layer that is to be manufactured; the thickness of the cutout 6 corresponds to the thickness of the component layer that is to be manufactured.

Fig. 3 shows a detailed view C of Fig. 2, which shows in detail the cutout 6 for the card support layer.

Alternatively, in a continuous manufacturing process, the base film and cover layer film may be supplied to the injection mold simultaneously with the chip and, where appropriate, the antenna, which where appropriate may also have been applied in a copper foil on a thin flexible film. After the mold has been closed, the hot-melt adhesive is again injected. After brief cooling and opening of the mold, the finished layer body may be transported further. This procedure affords the advantage that the base layer and cover layer may be used simultaneously as mold release agents in the injection mold. In all of the aforementioned production processes, the base film and/or cover film may be provided in an upstream or downstream manufacturing step with customary information and/or advertising imprints and/or security features such as a photo of the cardholder, a magnetic strip, an identification symbol in the form of a hologram or the like.

The advantages of the use of thermoplastic hot-melt adhesives to produce the component layers, in accordance with the invention, relative to the prior art, are:

- There is no need for support material which has to be produced separately by normal injection molding process.
- Milling work to produce the cutouts for the chip and the antenna is unnecessary.
- Also unnecessary is the separate adhesive bonding of chip and antenna into the cutouts.
- Following lamination with base film and cover film there is no "readthrough" of the unevennesses from conventional manufacture, since the card support layer on the one hand possesses a very smooth surface and on the other hand itself acts as an adhesive.

Although the principal field of application of the invention is in the production of contactless cards comprising electronic circuits (smart cards), this technology may also be used to produce transponders for the vehicle industry, in mechanical engineering and in container construction for the control of operations.